Dimensional verification of high aspect ratio micro structures using FIB-SEM

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Publication date:
2013

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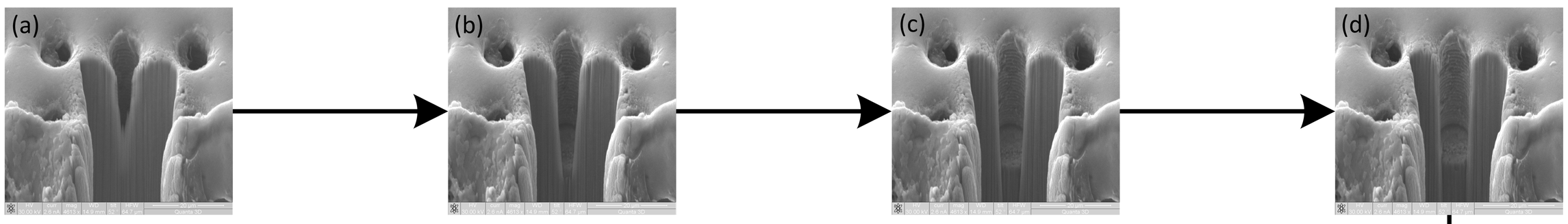
Problem definition

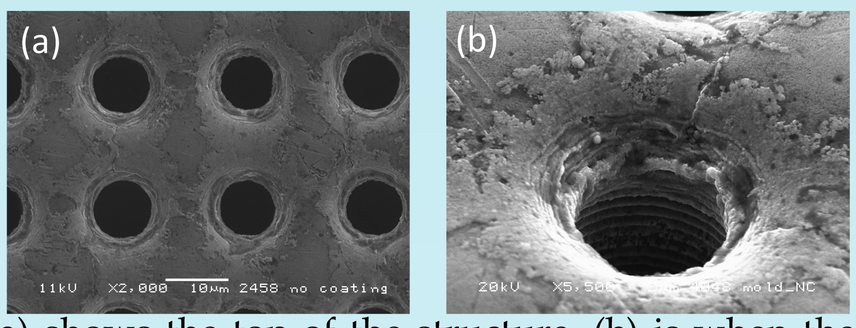
Micro-structured surfaces are increasingly used for advanced functionality. In particular, micro-structured polymer parts are interesting due to the manufacturing via injection moulding. A micro-structured nickel surface was characterized by focussed ion beam-scanning electron microscope (FIB-SEM) and then analyzed by Spip®. The micro features are circular holes 10µm in diameter and 20 µm deep, with a 20 µm pitch. Various inspection methods were attempted to obtain dimensional information. Due to the dimension, neither optical instrument nor atomic force microscope (AFM) was capable to perform the measurement. Via FIB-SEM, the process was recorded by images when slicing the sample layer by layer by ion-beam. In this way, the dimension and the geometry of the holes are characterized.



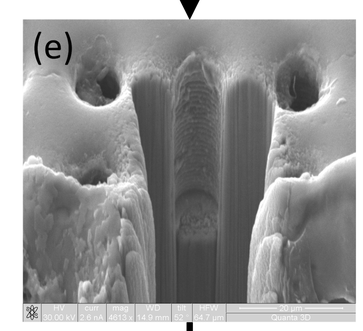
FIB SEM

A random hole was chosen to be observed. The side of the sample was positioned to be vertical to the ion beam. A block of material was removed by ion beam until the investigated hole was exposed. The sample was sliced from the side instead of from the top, to avoid debris falling into holes. The hole was sliced with a step of 200 nm, i.e. 200 nm thick material was removed in each layer during the milling. From (a) to (j), between two images the removed material is 1 µm thick.

Top view by SEM



(a) shows the top of the structure. (b) is when the sample was tilted up to 30 degree; the surface of the inner wall was shown, but the depth of the hole was still not illustrated.



Other instruments

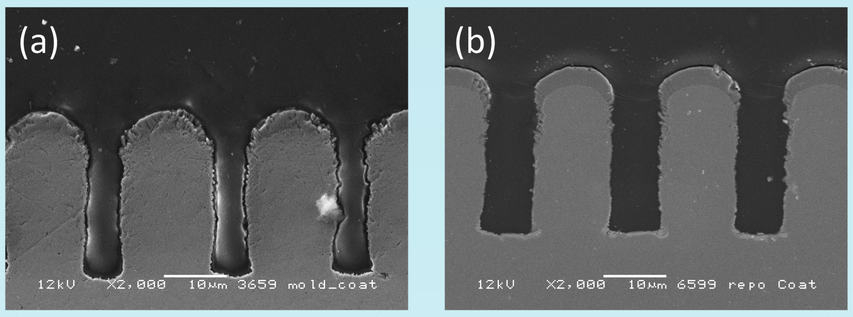
An optical microscope with Focus-Variation (Alicona®) was applied to measure the depth of the holes, however, the bottom of the holes cannot be "observed" by the microscope simply because the reflected light from the bottom was insufficient.

The depth measurement is beyond the measurement ability of an AFM, unless a customized cantilever is used.

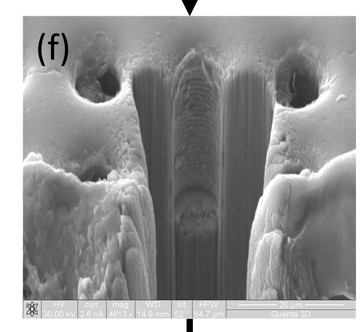
Conventional SEM has the difficulty to get sufficient illumination from inside the holes.

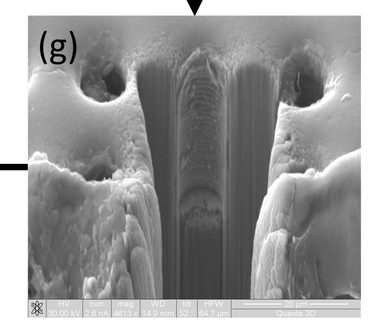
One often used method to investigate the geometry is to make cross section of the holes. The result is influenced significantly by the alignment and cutting process.

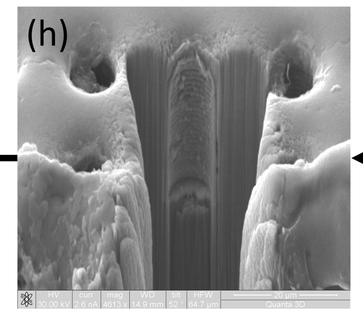
Cross section by SEM

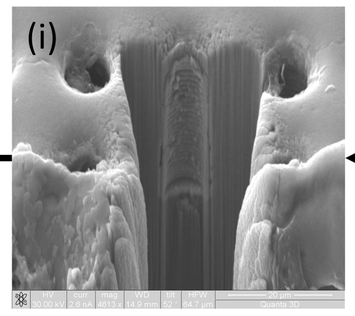


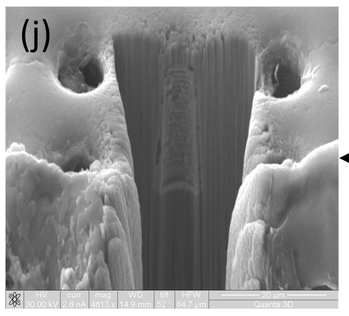
These two images are from a cross section. Sample (b) was polished further based on sample (a). Image (a) shows that the diameter of the hole is approximately 6.5 µm, while image (b) shows the diameter of the hole is 8.5 µm. The cross section preparing process has a significant influence.











Conclusion

A structured surface with holes 10 µm in diameter and approximately 20 µm deep was measured by conventional methods and a FIB SEM. The dimension was analyzed by SPIP® using x-y scaling tool. FIB-SEM picture (e) in was used for this analysis, since it illustrates approximately the central position of a hole. The diameter is 9.7±0.06 µm, the depth is 24.8±0.06 µm considering the tilted angle.